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Endovascular Repair of Aortic Rupture

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Objectives: *to report a single centre experience with endovascular repair of ruptures of the descending thoracic and abdominal aorta.*
Design: *retrospective non-randomised study in a university hospital.*
Material and methods: *between February 1997 and October 2002, endovascular repair of the aorta was performed on 125 occasions. In 20 cases, this was done as an emergency (nine ruptured infrarenal aortic aneurysms and 11 descending thoracic aortic ruptures). All patients underwent spiral computed tomographic angiography to assess the feasibility of endovascular repair and the size of the endoprosthesis.*
Results: *endovascular repair was successfully completed in all patients. Primary conversion to open repair was not necessary. Postoperative 30-day mortality was 5/20 (25%). There were major complications in 12/20 patients. No ruptures of the aneurysms occurred postoperatively. No primary endoleaks occurred, but in 4/20 (20%) secondary surgical interventions were required after a median follow-up of 12 months (range 1–42 months).*
Conclusion: *our early experience shows the feasibility of this technique with early results that compare favourably to those of emergency open repair. Further studies are required to assess the long-term efficacy.*

Key Words: Aortic rupture; Endovascular treatment; Complications.

Introduction

Aortic rupture due to trauma, aneurysm or dissection, is associated with a community-based mortality of 80–90%.[1–3,6–8] Although great strides have been achieved during the past decades by improving anaesthetic and surgical techniques, postoperative morbidity and mortality remain high. The affected population is usually of an older age with a variety of comorbidities that have an adverse impact on outcome.

Endoluminal repair may offer an alternative to conventional surgery.[4] Although, the long-term reliability of stent-grafts is hotly debated, their use may be justified in patients who present with an unacceptably high risk for open repair.[5] EVAR has the advantage of at least diminishing the physiological stress due to the operative procedure itself.[9]

For these reasons, we decided to manage patients with a ruptured aorta by means of stent-graft placement whenever possible. We report our five-year experience (the majority was performed during the last two years) with endovascular repair of aortic rupture.

Material and Methods

Patients

Between February 1997 and October 2002, 125 patients underwent endovascular repair of the aorta in our department. Of these 20 (16%) were treated as an emergency for an aortic rupture. Nine patients were treated because of a ruptured infra-renal aortic aneurysm, two suffered from a para-anastomotic pseudo-aneurysm and one had an aorto-enteric fistula. Eleven patients underwent endovascular repair of the descending thoracic aorta because of traumatic rupture ($n = 3$), a rupture of a descending thoracic aneurysm ($n = 5$) and rupture of a type B dissection ($n = 3$). Patients were referred from a variety of sources including the local community and other vascular units. Patients from other hospitals were considered unfit for conventional open repair and were referred specifically for consideration of endovascular treatment; 14 of our 20 (70%) patients were referred from another hospital. The median duration of symptoms prior to admission was 24 h (1 h–5 days).

During the study period 68 patients underwent an open repair for aortic rupture: 40 were treated because of a ruptured infrarenal aortic aneurysm, 6 suffered from an aorto-enteric fistula, 14 underwent repair

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because of traumatic rupture of the descending thoracic aorta and 8 were treated because of rupture of a thoracic or thoraco-abdominal aneurysm (Fig. 1). The choice of endovascular repair was dependent on the availability of the endografts (which increased during the study period), the suitability for endovascular repair and the surgeon's preference. All patients underwent spiral-computed angiography (CTA) of the aorta. The diagnosis of ruptured aorta was confirmed on CTA and the morphology was assessed for suitability for endovascular therapy. Informed consent for endovascular repair was obtained from the patient or his relatives.

Operative technique

All the endovascular repairs were performed in the operating room under fluoroscopic control, using a mobile digital C-arm image intensifier. For the thoracic cases, transoesophageal echocardiography (TEE) was also used. All patients were treated under general anaesthesia, with invasive radial and, if necessary, pulmonary artery monitoring. For fluid management in aortic rupture, the rule of "as little fluid as possible" was applied. Nitroprusside was often used to treat a systolic blood pressure higher than 100 mmHg.

One or both femoral arteries were exposed, an introducer sheath 7 Fr was used for cannulation of the artery, and a 0.035 terumo guidewire was introduced under fluoroscopic control, followed by a 5 or 6 Fr pigtail catheter. Most patients received heparin (5000 IU) intravenously. Digital substraction angiography in breath-hold technique was performed to visualize the anatomy of the aorta and the level of the renal arteries, or the left common carotid and left subclavian artery.

An exchange for a 260 cm Amplatz superstiff wire was performed over which the stent graft was introduced following exchange of the access sheath.

We oversized the stents for 10–20% compared to the diameter of the aortic neck on CT scanning for adequate fixation. The prosthesis was deployed with breath-hold and lowering of the patient's blood pressure, especially in the thoracic aortic ruptures, by means of nitroprusside. If indicated, a polymeric balloon was inflated to obtain optimal sealing of the stent graft. A completion angiogram in breath-hold technique was obtained in each patient.

A total of 18 thoracic stent grafts were implanted in eleven patients. The devices used included 1 Aneurx device (Medtronic), 2 Gore TAG devices (W.L. Gore) and 15 Talent (Medtronic) devices in the remaining eight patients. In the abdominal aortic ruptures ($n = 9$), the endograft consisted of a bifurcated device in three patients, a straight tube in one patient and an aorto-uni-iliac device in five patients. The contralateral common iliac artery was obliterated by means of an occluder and a femoro-femoral bypass was performed in four patients (Fig. 2). The devices used included 3 Vanguard (Boston Scientific), 1 Excluder (W.L. Gore) and 5 Talent (Medtronic). The type of stent graft was selected upon availability and surgeon's preference.

Fig. 1. Preoperative CT-scan of a ruptured infrarenal aortic aneurysm after previous endovascular repair.

Fig. 2. Postoperative CT-scan after insertion of an aorto-uni-iliac endoprosthesis with an occluder.

Routine surveillance was done according to the Eurostar protocol, including contrast-enhanced spiral CT scans prior to discharge and at 3, 6, 12 and 18 months after the procedure and yearly thereafter. An X-ray of the abdomen or thorax was taken yearly.

Results

Infrarenal aorta

All nine patients were men, with a median age of 70 years (range 53–77 years), median duration of symptoms of 24 h (1–72 h), and median transfer delay of 6 h. The median aneurysm diameter was 80 mm (range 42–90 mm). In two patients, free blood was present in the abdominal cavity and seven patients had a ruptured contained aneurysm. Five patients were in shock with a systolic blood pressure <70 mmHg and one had a systolic blood pressure below 50 mmHg (Figs 1 and 2). The median duration of EVAR was 150 min (range 80–420 min).

EVAR was completed successfully in all patients. One patient, who was treated with an aorto-uni-iliac device with femoro-femoral bypass because of a ruptured aorto-iliac aneurysm, required an immediate laparatomy because of a proximal type IA endoleak. A Dacron sling was placed around the proximal aorta to control the endoleak and the left internal iliac aneurysm was oversewn. No iliac arteries or renal arteries were blocked in the remaining patients. Two type II endoleaks were present. Device related or arterial complications did not occur.

Postoperatively, all patients were admitted to the ICU, median stay was five days (range 1–17 days) and the median hospital stay (including ICU) was 15 days (range 5–62 days). There were two secondary interventions in the peri-operative period. One patient suffered from an abdominal compartment syndrome, which was treated by a translumbar extraperitoneal decompression the day after EVAR. Another patient with only one functional kidney developed acute tubular necrosis. Duplex scanning suggested a tight stenosis of the right renal artery. Angiography performed three weeks later failed to visualise the stenosis caused by the stent due to projection interference. It was impossible to get a guide wire or any angiographic catheter through the ostium and so a hepatorenal bypass was performed with saphenous vein. Several weeks later he suffered from biliary peritonitis, laparatomy was performed and showed an iatrogenic perforation of the common bile duct. This was treated but the patient died shortly afterwards. Other major complications were pneumonia ($n=2$), a pseudoaneurysm of the brachial artery ($n=1$), which was used to perform an angiogram preoperatively and cardiac decompensation ($n=2$). There was one other postoperative death due to massive lung embolism and multiple organ failure 17 days postoperatively in a patient who developed paraplegia after both internal iliac arteries were blocked intentionally during repair of a ruptured abdominal aorto-iliac aneurysm.

At follow-up, two other patients had died. One patient died because of recurrent pneumonia, 42 months after EVAR. The other patient died of a recurrent aortoduodenal fistula with bleeding, 27 months after EVAR. The endoprosthesis was explanted and a cryopreserved aortic allograft bifurcation was implanted but he died of multiorgan failure. One patient was lost from follow-up. The remaining four patients are alive with a CT follow-up of 3–18 months. CTA examination has revealed that all four aneurysms are successfully excluded, without endoleaks. No further secondary interventions were required after the perioperative period and no secondary rupture of an aneurysm has occurred.

Descending thoracic aorta

There were seven men and two women with a median age of 77 years (range 27–83 years), median duration of symptoms 48 h (range 2 h–5 days), median transfer delay 48 h (range 1 h–5 days). Nine patients belonged to the ASA IV–V group. In all patients preoperatively CTA was taken, in four patients aortography was performed and TEE in three patients. Four patients were in shock (systolic blood pressure <70 mmHg) (Figs 3 and 4). The median duration of EVAR was 110 min (range 75–360 min).

In all patients, the stent grafts were successfully deployed in the intended position. Conversion to open procedure was not necessary. Technical success was achieved in all patients with exclusion of the aneurysm, coverage of the entry tear of the dissection and increase of the true aortic lumen. At completion angiography no endoleaks were observed. In five patients, the left subclavian artery was covered but only one patient required a subclavian-carotid bypass. In one patient, who was unfit for conventional open repair, a free rupture of the thoracic aneurysm occurred intraoperatively. In another patient the second stent graft was misplaced because of losing the position of the Amplatz guide wire, which should normally stay in place in the ascending aorta. This occurred during open repair of a perforated iliac

Fig. 3. Preoperative CT-scan in an acute type B dissection with rupture.

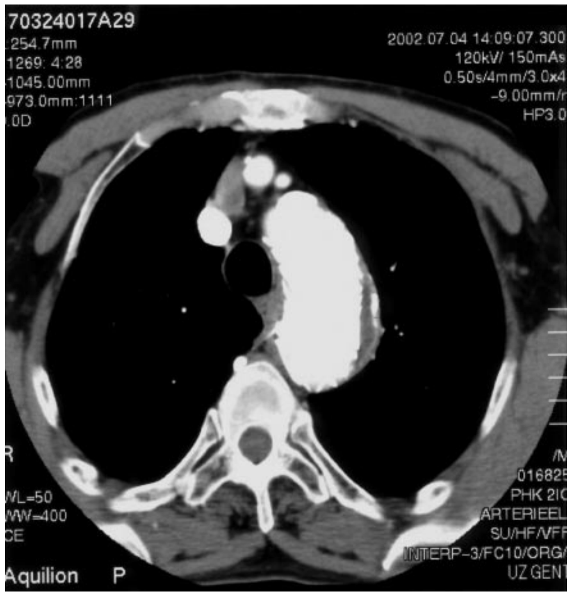

Fig. 4. Postoperative CT-scan after endovascular repair.

artery. It was resolved by inserting two other stent grafts who compressed the wrongly placed endoprosthesis. A total of four stent grafts were, therefore, placed in this patient. In two patients perforation of the iliac artery occurred during manipulation of the device and an urgent retroperitoneal approach was made to repair the iliac artery.

Postoperatively, all patients were admitted to the ICU, the median stay was seven days (range 2–28 days) and the median hospital stay (including ICU) was 20 days (range 10–47 days). Three patients required open decompression of the pleural hematoma, two by means of a thoracoscopy, one by means of a chest tube. Two other secondary interventions were performed in the perioperative period. In one patient on chronic hemodialysis a retroperitoneal hematoma occurred at the introduction site (left iliac artery). This was explored but no active bleeding was found and he died on day 20.

The other patient, with intra-operative rupture of the thoracic aneurysm, had ischemia of his right leg (after iliofemoral bypass because of perforation of the iliac artery). Thrombectomy was performed but as there was no outflow an above knee amputation was done. He died on the third postoperative day.

In the group treated because of ruptured thoracic aortic aneurysms (RTAA), four out of five patients died in the perioperative period after multiple organ failure. Two of them have been described above. Another suffered from pontine ischemia, in this patient the left subclavian artery was covered by the device and no bypass or transposition was performed. They all belonged to ASA group IV or V and were all unfit for open repair. Other major complications that occurred were pneumonia,[6] ATN,[3] ileus after retroperitoneal approach,[2] and cardiac failure.[4] None of the patients developed paraplegia.

At follow-up, the remaining seven patients are still alive (median duration of follow up nine months, range 1–12 months). The three patients treated because of a type B dissection with ruptured aneurysm are symptom free. In one patient, there is a type IA endoleak but the aneurysm remains stable in diameter. The other two patients show complete thrombosis of the false lumen in the thoracic aorta and an increase of the true lumen of the aorta. The only patient alive after endovascular repair of an RTAA has a completely excluded aneurysm with no endoleak on his CT scan at I month.

Discussion

Endovascular repair for rupture of the abdominal aorta was first described in 1994[10] but only recently some larger series were published.[11–14] This seems surprising because the potential gain in reduced mortality and morbidity seems much higher in ruptures than in elective repair.[13] Although in one of these series mortality was still elevated (45% in 21 patients),[11] three other series showed favourable and consistent results with mortality rates of 12–17% in series of 21–25 patients.[12–14] Our results are in line with these favourable results, with a 30 day mortality rate of 11% (1/9).

The feasibility of endovascular repair for aneurysms of the descending thoracic aorta was first reported by Dake in 1994.[15] This was followed by several reports describing the use of endografts in traumatic ruptures and type B dissections[16–18] (Fig. 3). In traumatic ruptures the use of endografts seems attractive thanks to its simplicity especially in multiple traumatized patients. However, doubt still exists concerning the long term durability and integrity of these endografts especially in young patients. In patients with ruptured thoracic aneurysms or rupture after acute dissection comorbidity and perioperative mortality is even higher than in ruptured abdominal aneurysms. In three series of ruptured thoracic aorta (traumatic rupture combined with ruptured aneurysms) treated with endografts mortality was 1/10,[19] 2/11[16] and 1/16,[14] respectively. In our series all patients with traumatic rupture and rupture due to acute type B dissection[3] survived. We had a high mortality in patients with ruptured atherosclerotic aneurysms (4/5) but it has to be noted that all these patients belonged preoperatively to ASA-class IV and were unfit for open repair.

One of the major concerns regarding endovascular treatment in these emergency situations is the time delay during preoperative work-up. Accurate preoperative imaging is of paramount importance prior to successful endovascular exclusion of an aortic rupture. Contrast-enhanced spiral computed tomography is the gold standard imaging modality. Sole reliance on intra-operative imaging would appear attractive for patients undergoing endovascular treatment, however, confirmation of rupture and accurate interpretation of aortic morphology are not assured by intraoperative angiography, nor does it provide sufficient information for accurate endograft sizing.[20] Several studies show that preoperative delay and transfer to a regional vascular unit does not necessarily prejudice the outcome of patients undergoing open repair. As we are able to obtain a spiral CT-scan within 15 min thanks to the location of the CT-scan within the emergency department this delay was not considered a significant contra-indication to endovascular repair.

Local anaesthesia during endovascular repair may prevent some of the adverse cardiovascular and respiratory features of general anaesthesia. Muscular relaxation resulting in loss of tamponade and hypotension is one of the most significant complications. EVAR may avoid this problem if the operation is performed under local anaesthesia.[20] Early reports on the feasibility of local anaesthesia have proven contradictory.[11,21] In our experience, the severe pain and discomfort associated with aortic rupture makes it very difficult for the patient to keep still during the procedure. Therefore, we prefer to perform the repair under slight general anaesthesia without muscle relaxation.

Because the sheaths for delivery of the endoprostheses are quite large in diameter, especially in thoracic endografts, there is a risk of perforation of the iliac artery used for access, especially if that artery is excessively tortuous, stenosed or calicified. In these cases a retroperitoneal access to the common iliac artery should deliberately be chosen.[22] In our experience, four patients (20%) had a complicated inguinal introduction of the device, necessitating an alternative arterial access (retroperitoneal iliac artery) or emergency iliac artery repair.

As the retroperitoneal hematoma is left untreated in endovascular repair, ileus is a frequent complication. If huge, some patients may even develop an abdominal compartment syndrome.[12] This should be treated by translumbar extraperitoneal decompression in the days following the initial procedure as was necessary in one of our patients. The presence of endoleaks is a major concern after the treatment of ruptured aortas as these might be responsible for continued bleeding. Strangely enough this does not seem to be an issue in clinical practice. The presence of the retroperitoneal hematoma might contribute to the sealing of the lumbars and other sidebranches.

In summary the endovascular approach to the management of aortic rupture appears an attractive one and our preliminary results seem promising. However, questions remain regarding the cost, generalisibility, efficacy and durability of the technique. Whether the endovascular method will prove to be a valuable alternative to open repair, will only be answered by further experience, longer follow-up and properly conducted clinical trials.

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